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AUTHOR Razel, Micha
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ABSTRACT

This paper attempts to refute the assumption that early motor development is determined genetically and is not influenced by environmental factors. The paper re-examines three studies which are consistently cited as providing evidence for a maturational theory of motor development: the "early training study" by Gesell and Thompson, the "swaddling study" by Dennis and Dennis, and the "deprivation study" by Dennis. A reanalysis of the Gesell and Thompson data indicates that after the training of both twins, the performance of the twin who had received the greater amount of training significantly exceeded that of the control twin. These differences disappeared only when the twins had reached a performance ceiling. In the Dennis and Dennis "swaddling study", both the swaddled and the unswaddled babies were retarded in motor development. The present paper argues that this result can be interpreted as providing support for the view that a lack of learning experiences can impede motor development. Data from the "deprivation study", in which two twins were raised in virtual isolation from 2-14 months of age, indicated that the twins were consistently retarded in their motor development during the course of the study and that this retardation increased the longer the twins remained in isolation. According to the present paper, data from all three of these studies indicate that motor development can be accelerated by training and slowed down by conditions of deprivation. (BD)

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The Evidence Against Learnability of Early Motor Skills Reconsidered

Micha Razel

School of Education, Haifa University, Haifa 31999, Israel

Abstract

It is commonly held that early motor development is determined primarily by maturation. This opinion seems to be based mainly on three influential studies: (a) The "early training" study by Gesell and Thompson (1929); (b) the "swaddling study" by Dennis and Dennis (1940); and (c) the "deprivation study" by the same researchers (Dennis, 1938). The aim of the paper is to show that a proper analysis of these studies refutes the conclusion offered in them that early motor development is not affected by learning conditions. Providing a correct analysis for the data resulting from the deprivation study is of special interest because it seems to be the only study where longitudinal data have been collected from individuals experimentally raised in a deprived environment for a long period of time.

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The Evidence Against Learnability of Early Motor Skills Reconsidered[a]

Micha Razel

School of Education, Haifa University, Haifa 31999, Israel[b]

The assumption that early motor development is determined genetically and is not influenced by environmental factors is widely accepted by psychologists. For example, Mussen Conger and Kagan (1963) claim that "growth changes and maturation of neural and muscular systems--rather than environmental conditins, experiences, or practice--determine when the child will sit, stand and walk" (p.108). Educational psychologist Ausubel (1959) says that the course of motor development "can be specified apart from relevant environmental conditions" (p. 249). Judging from textbooks (e.g., Hilgard & Atkinson, 1967; Ziv, 1975) or literature reviews (e.g., Kohlberg, 1968), it seems that the empirical evidence on which this common assumption is based consists mainly of three well known studies. The main goal of this paper is to demonstrate that when these studies are analyzed properly, they do not unambiguously support the assumption that motor development is determined by internal maturational factors. Rather, they provide support for the opposite point of view, namely, that motor development is

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[a]This paper was presented at the meeting of the American Psychological Association, San Francisco, August 1977, and is based on Razel (1976, 1977b)

[b]Address correspondence to author's home address: 30 Ovadia Somech St., Jerusalem 94526, Israel

dependent upon learning conditions.

The Early Training Study

Gesell and Thompson (1929, 1943) used a pair of identical twins, "Twin T"--for Treatment--and "Twin C"--for Control--as subjects in an experiment in which they provided the two infants with training of motor skills such as creeping, standing, walking and climbing. Twin T received six weeks of trainig when she was 46 weeks old while Twin C received two weeks of trainig when she was 53 weeks old. One finding was that Twin C learned faster at the later age than did Twin T at the earlier age. Gesell and Thompson concluded that maturation is the principal factor in development.

Our disagreement with Gesell and Thompson's conclusion is based on the following considerations. First, the faster learning rate of Twin C can be explained not only by a concept of greater maturity but also by a learning theory which assumes that an older individual learns faster because of the larger amount of knowledge that he has acquired. Since Twin C was not kept "in cold storage" during the period in which her sister received training, it can be assumed that she received the same usual learning opprtunities that every child receives during this period, and that the knowledge derived from them helped her progress at a faster rate when she was given training. In other words, since no care was taken to keep constant the learning opportunities that the twins had received up to their training, this study does not, in fact, provide us with any unequivocal evidence that motor development is determined by maturational or genetic factors.

Second, contrary to the assumption of no environmental effect on motor development, the greater amount of training given to Twin T at an earlier age seemed to have advanced her motor development. This may be concluded from data supplied by Gesell and Thompson (1943, Table 1) of 16 comparisons in which one twin exceeded the other in some motor achievement. In each of these comparisons, which referred to creeping, standing, walking and climbing, the better performance was always that of Twin T. This was the case even though the two sisters' motor development was essentially the same before the training had begun. Twin T's superiority is significant when evaluated by a sign test ($p < .02$). The conclusion is, therefore, that providing training significantly advanced motor development.

Gesell and Thompson's claim that "there is no conclusive evidence that practice and exercise even materially hasten the actual appearance of types of reaction such as stair climbing" (p. 216) is thus simply incorrect. What could have caused Gesell and Thompson to arrive at their conclusion? It seems that it was based on the fact that Twin T's superiority disappeared with time. But the difference in achievement disappeared only when the twins reached a ceiling of performance. For example, the difference in walking disappeared only half a year after the end of the experiment and five months after the twins had started to walk; the difference in the time needed to climb a staircase disappeared when the twins reached a ceiling of about 7 sec and only a year after the end of the experiment.

Is motor training desirable if the difference in motor development disappears with time? The question lies outside the immediate goal of this talk which is to evaluate the evidence for the claim that motor development is not affected by learning opportunities. Therefore, only a short answer can be given. It seems to us that the importance of early training of motor skills lies in the greater ability of the infant who has early control of motor skills, such as walking, to derive knowledge and learn from its environment. Even when the advantage in mastery

of the motor skill in which training was given, disappears, the cognitive advantage resulting from this early superiority may very well remain[1].

The Swaddling Study

Dennis and Dennis (1940) studied the custom of American Hopi Indians to tie their babies to a 75 by 30 cm flat wooden board, and the effect of this swaddling on the age at which the infant first walks alone. The Hopi infant, lying on his back, was bound to the board so that it could not move its arms or legs. During the first three months of life the infant spent all the time on the board: it was taken off the board only when it was cleaned. When it grew older, the infant was allowed to spend an increasing amount of time off the board. The average age at which the board was discarded was nine months, with a range of between half a year and a year. Dennis and Dennis compared 63 infants that had been swaddled to 42 infants that had not. The latter had been reared in two Hopi villages where the inhabitants were influenced by American culture to the extent of giving up the use of the board.

Dennis and Dennis found that the mean age of walking alone was 15 months both in the group of swaddled infants and in the control group. Their conclusion was, therefore, that restrictions on movement and on access to motor learning opportunities do not affect the age of walking alone.

The difficulty with this conclusion is that the Hopi mean age of walking is late in comparison to what is normally found, for example, in groups of children from Western society. Dennis and Dennis themselves tried to estimate the extent of retardation by comparing the Hopi mean walking age with the means reported in nine studies

of other groups of infants. The Hopi mean age was 1.00 to 1.8 months later than the means reported in these other studies. The means for the swaddled and unswaddled Hopi groups were between 2.5 and 5 standard errors behind the means of the other groups and were, therefore, retarded to a statistically significant degree.

The motor retardation of the swaddled Hopi infants is consistent with a conclusion opposite to the one reached by Dennis and Dennis, i.e., that motor development is slowed down by poor environmental conditions.

What remains to be explained is the retardation in motor development of the unswaddled Hopi infants. The only information we have about the way in which these infants were raised is Dennis and Dennis' report that except for not being swaddled, the rearing conditions of the control infants remained "virtually unchanged" (p. 77) relative to those of the swaddled infants. This may mean, that they too were kept on their backs during the whole day, excluding only feeding and cleaning; that they too were not held in a vertical position or in a sitting position.

But even if the unswaddled infants were kept on their backs as much as the swaddled ones, the question may still be raised why the swaddled infants were not more retarded in walking than the control infants. This question was asked, for example, by Dennis and Dennis. A possible answer may be that those movements that can be made by an unswaddled baby that is kept lying on his

back, do not facilitate the development of skills involved in walking. There are several empirical findings that support this assumption. For instance, Dennis (1960) himself, twenty years later, in his study of Iranian orphanages, found that out of 33 children who were in their fourth year of life, and who were kept lying on their backs all their life, only 5 were able to walk alone. I.e., these children were not able to walk in spite of their age and in spite of the fact that they had complete freedom to perform the movements that can be made by an infant who lies unswaddled on his back.

To summarize our discussion of the swaddling study, we have pointed out that the swaddled Hopi infants were slow in their motor development, which, it seems to us, should disqualify this study from being repeatedly quoted as giving strong support to the point of view that motor development is not affected by the availability of learning opportunities. We have found that the control group was similarly retarded. Dennis and Dennis' report does not contain enough information about the way the unswaddled infants were raised to give conclusive support to a learning explanation of their retardation. But the little that is reported does not preclude such an explanation.

The Deprivation Study

Dennis and Dennis (Dennis, 1935a, 1935b, 1935c, 1938, 1940, 1941; Dennis & Dennis, 1951) raised two fraternal twins, Del and Rey, in conditions of deprivation, from the second and till the 14th month of life. The twins were kept lying on their backs in an isolated room. The infants were taken out of their cribs only when fed or cleaned. But during these activities, Mr. and Mrs. Dennis did not interact with the infants in any way except for the necessary mechanical operations.

Dennis compared the twins' development to the developmental norms published by him and his wife in 1937 (Dennis & Dennis, 1937). The norms were based on 40 biographies of normal infants and included the median and the range of the ages of first appearance, as reported in the biographies, of 50 behavioral items. Dennis (1938) found that "With respect to the items whose upper limits appear within the first seven . . . months, the twin subjects with few exceptions fall within the age range of children with normal environment".(p. 153). Dennis concluded from this that the infants' development was not different from that of normal children.

What happened to the twins during the second half of the experiment? Dennis claimed that their development during this period showed "some records behind the range of comparison cases" (p. 154). This description is somewhat of an understatement since the achievements of each twin fell beyond the range given in the norms, in 12 out of the 17 relevant items.

We know very little about the twins' development subsequent to the experiment. Dennis tells us only this. In the 4th and 5th year of her life it became apparent that Del suffered from severe motor disabilities. She was taken to the hospital where it was found that there was nothing wrong with her bones or muscles and where she was given a diagnosis of a mild left hemiplegia that could have resulted from brain injury during birth. Dennis says that this diagnosis explains the (Stanford-Binet) I.Q. of 70 that Del had at 4½ years of age. Reys I.Q. at the same time was 107 and Dennis claims that her development was normal.

How does Dennis explain the fact that during the second half of the experiment the twins' achievements fell outside the range

of the comparison group for most of the behavioral items? As to Rey, Dennis claims that if the normative sample had been larger the age ranges would have been larger and Rey's results would then have fallen within the ranges of "normal" development. The fact that Del fell outside of the norm's ranges is not to be attributed, according to Dennis, to the experimental conditions since in the first half of the experiment, when the conditions of deprivation were the strictest, no retardation could be observed in her development. The slow rate of development must, therefore, be attributed to the mild left hemiplegia and to a brain injury.

The post-hoc nature of the use of brain injury as an explanatory concept is illustrated by the following fact. In a paper published by Dennis three years earlier, when the twins were three years old, Dennis (1935c) specifically rejected the possibility that the twins were "retarded by organic motor disabilities" (p. 29).

The statistical test used by Dennis to compare the twins' development to his norms is methodologically inadequate on two main accounts. First, Dennis checked if the twins fell within the normative range but not <u>where</u> in the range. But according to any developmental theory that accepts that learning factors play a role (even if only a secondary one) in development, the position, relative to the normative range, of any individual achievement is determined, at least partially, by the learning opportunities that had been available to the individual. Therefore, to demonstrate that the experiment did not have an effect, one must show that the twins' achievements did not fall regularly in the slower part of the normative range.

Second, Dennis did not compare the developmental record of the twins to that of the slowest infant in the comparison group but to a collection of the worst performances contributed by different individuals in the group. It must

be remembered that a child in the normative group who contributed the slowest age to one item may have reached other items in relatively early ages. Thus, if the twins' data fell in the slower parts of the age ranges of most items, the twins' development may in fact have been much worse than the development of any individual in the sample.

To perform a statistical test that would overcome these difficulties it was necessary to compute on Dennis and Dennis' (1937) norms, a mean and standard deviation for each item and to translate the ages of the item's first appearance for each child into standard scores. Next, a mean of the standard scores of each subject was computed, providing a single developmental index that summarized the individual's relative standing over the norm's various items. Two such developmental indeces were computed. The first was based on the first 28 items, i.e., the items that were related to development in the first seven months of life. The second was based on the last 17 items that were related to the second half of the experiment. The analysis indicates, that in the first seven months of life Rey's developmental index was 2.06 standard deviations behind the average score in the comparison group; Del's index was 1.72 standard deviations behind. For the last 17 items, it was found that the retardation of Rey's index increased to three (3.04) standard deviations and that of Del's to five (4.96). In other words, the retardation of both twins in both parts of the experiment was statistically significant.

This analysis throws a completely different light on the study

of deprivation. First, the two twins were retarded in their development in the first half of the experiment. Second, the retardation grew the longer the twins remained in the depriving conditions. Dennis' argument that the motor disabilities and the low I.Q. of Del at 4½ years of age could not be attributed to the experiment because there was no retardation in her development while the experiment was in process is contradicted by the present analysis. According to this analysis, it is not Del's I.Q. and motor disabilities at age 4½ that are surprising and that need to be explained by a cortical injury during birth. Rather, it is Rey's I.Q. of 107 at 4½ years that is incongruous with her development during the first year of life. It is, of course, possible that after Rey had been returned to her mother at the end of the experiment, there was something in the environment or in the way she interacted with it that compensated for some of the effects of the experiment. It is to be regretted, however, that in spite of promises to do so (Dennis & Dennis, 1951), no details about the twins' later development have been reported. Such a report could help us decide whether the I.Q. scores earned at 4½ were representative of the twins later development.

Dennis (1938) summarized the experiment saying that it showed that "the infant within the first year will 'grow up' of his own accord" (p. 157). This conclusion seems unjustified. It is unfortunate that the lessons learned from this unique experiment by developmental psychologists is confined to this summary given by Dennis (see, for example, Biehler, 1974, p. 101; or White, 1971, p. 27).

The Motor Training of the Twins.

In a separate paper published in 1935, when the twins were three years old, Dennis (1935c) described his efforts to accelerate, through training, the nine-months-old twins' undeveloped motor skills. His conclusion was that "each response was readily established when practice was offered" (p. 30). This conclusion is quoted regularly in the literature, but it is not exactly correct.

Not later than the 14th month, new knowledge was acquired that indicated that the effects of a year-long deprivation could not be repaired "readily". This knowledge was not reported till 1941 (when the twins were nine years old). Here Dennis (1941) tells about the decision to return the twins to their mother and to "bring [Del] up to the normal performance for her age" (p. 170). Dennis reports how he and his wife tried to cause Del to creep, stand and Walk and how "she would not try" (p. 170). Dennis concluded, "our efforts at training were apparently without effect" (p. 170), which clearly contradicts his conclusion of 1935.

To sum up, we reviewed three studies which are considered the strongest evidence in support of the claim that motor development is genetically determined and is not affected by learning opportunities. We tried to show that these studies do not contain any evidence requiring us to assume that motor development is genetically determined in a greater degree than any other behavior. An adequate analysis of the data contained in these studies indicates that motor development can indeed be accelerated by training and slowed down by conditions of deprivation.

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Footnotes

[1]A fuller theoretical discussion of the effects of training in one task on cognitive development in general is given in Razel (1977a). It is pointed out that under the assumption that mastery of one task makes the learning of other tasks easier, it follows that the benefit to cognitive growth resulting from early mastery of a task increases with time. Even when the advantage in the original task disappears, new gaps form in an ever increasing number of tasks.